PUBLIC SERVICE CORPORATION

OF

NEW HAMPSHIRE

SEABROOK STATION UNITS 1 & 2

PROBABILITY ESTIMATE OF TEMPERATURE EXTREMES

FOR SEABROOK, NEW HAMPSHIRE

PREPARED BY: United Engineers & Constructors, Inc.

DATE: January 1983

8304220004 830420
PDR ADOCK 05000443
E PDR

TABLE OF CONTENTS

Section		Page No.
1.0	INTRODUCTION	1-1
	1.1 Purpose of Study	1-1
	1.2 Study Summary	1-2
	1.2.1 Representativeness Analysis	1-2
	1.2.2 Return Period Extreme Temperatures	1-3
2.0	STUDY METHODOLOGY	2-1
	2.1 Selection of Variables and Data Bases	2-1
	2.2 Data Bases	2-3
	2.2.1 Available Raw Data	2-3
	2.2.2 Previously Analyzed Data	2-3
	2.2.3 Representativeness Analysis	2-4
	2.3 Estimation of Return Period Statistics	2-4
	2.3.1 Assumption of Data Distribution Characteristics	2-4
	2.3.2 Computational Methodology	2-5
	2.3.2.1 Hourly Temperatures	2-5
	2.3.2.2 Averaging Period Temperatures	2-6
	2.4 Derivation of Temperature Progression Data	2-7
3.0	STUDY RESULTS	3-1
	3.1 Representativeness Analysis	3-1
	3.2 Fifty and 100-Year Return Period Temperatures	3-2
	3.3 Temperature Progression	3-4
4.0	CONCLUSIONS	4-1
5.0	REFERENCES	5-1

1.0 INTRODUCTION

1.1 Purpose of Study

This extreme temperature analysis is designed to establish the outdoor dry bulb temperature which may be expected to recur once in every 50 or 100 years for confirmation of the adequacy of safety-related equipment design.

Since the response of many safety-related facility components to extreme conditions is characterized by a certain degree of thermal inertia, this study also develops extreme temperatures (with return periods of 50 and 100 years) for varying temporal averaging periods.

Additional information required to assess the degree to which thermal inertia is important in offsetting extreme temperature conditions is also required. This includes the determination of the actual hourly temperature progression data for the warmest and coldest contiguous 24 hours associated with the observed record maximum and record minimum hourly temperature, as well as a hypothetical hourly temperature progression for the warmest contiguous 24 hours associated with the 100 year return period maximum hourly temperature.

This analysis is designed to be as site-specific as possible considering the fact that only a relatively short (five years) record of hourly temperatures is available from the onsite meteorological station. Much longer periods of record are available from military and climatological stations in the general site region. Since the majority of this analysis requires hourly temperature data, the only nearby station recording hourly temperature data, Pease Air Force Base (AFB), is selected. Temperature data from other area stations are then used to demonstrate that temperatures recorded at Pease AFB are reasonably representative of the general site region.

1.2 Study Summary

1.2.1 Representativeness Analysis

Temperature data from Pease AFB were selected for the analysis since it is the closest station to the site collecting temperature data on an hourly basis as required for this analysis. To evaluate the regional representativeness of Pease AFB, temperature data were obtained in various forms for extended periods of record for numerous meteorological and climatological stations in the New England region near the site. These data included temperatures from all stations used in the NUREG/CR-1390 analysis[1] as well as additional data from Rockport, Massachusetts, Sanford, Maine, and Greenland, New Hampshire.

Analysis and comparison of data from these stations as well as consideration of other factors such as proximity to the coastline, station elevation, and period of record have led to the following conclusions:

(1) The temperature conditions at Pease AFB are very similiar to those experienced at the Greenland, N.H. station due to the relatively small distance between these stations. The Greenland station, however, recorded an extremely limited amount of temperature data.

(2) Sanford, Maine and Rockport, Massachusetts experience temperature conditions more and less extreme, respectively, than Pease AFB. These stations demonstrate the range of possible conditions in the general site region.

(3) Pease AFB exhibits more moderate temperature extremes than indicated for the region by the NUREG/CR-1390 analysis. The data base used to develop the isotherm maps in NUREG/CR-1390

does not contain any of the stations referenced above. The isotherms in the site region as presented in CR-1390 are heavily influenced by data from inland stations.

(4) Comparison of Seabrook and Pease AFB frequency distributions for hourly observations as well as for daily maximum and minimum temperatures shows that the Pease AFB data represent the Seabrook site fairly well. This comparison was conducted based on a concurrent five-year period of record at both stations.

The main conclusion of the representativness study is that Pease AFB temperature data are reasonably representative of temperatures recorded in the general site region. The Pease AFB measurement location and topography does differ from the site in two ways - it is farther from the ocean, and there is a significant body of water (Great Bay) to the south and west of the Air Force Base. These differences do not, however, produce temperature conditions unrepresentative of the general site region or of the site itself.

1.2.2 Return Period Extreme Temperatures

Table 1-1 summarizes the calculated 50- and 100-year return period extreme temperatures for Pease AFB. The 50- and 100-year extreme value dry bulb temperatures calculated for Pease AFB (only 10 miles north of the Seabrook site) are recommended for use at the Seabrook site. The results for Pease AFB are based on the currently available 25 years of data.

Table 1-2 presents a hypothetical expected hourly temperature progression for the warmest contiguous 24-hour period in association with the 100-year return period maximum hourly temperature for Pease AFB. Table 1-3 presents the observed hourly temperature progression for the warmest 24-hour period containing the maximum observed hourly temperature for Pease AFB. Table 1-4 summarizes the frequency of hourly temperatures recorded at Pease Air Force Base. As shown in this table, the hourly temperature at Pease AFB equals or exceeds 88°F and 91°F for .463 percent and .104 percent of the valid hourly observations, respectively, and is less than or equal to 0°F and -5°F for .356 percent and .111 percent of the valid hourly observations, respectively.

TABLE 1-1

SEABROOK EXTREME TEMPERATURE ANALYSIS
MAXIMUM AND MINIMUM TEMPERATURES
FOR 50- AND 100-YEAR RETURN PERIOD
RECOMMENDED FOR USE AT SEABROOK SITE

Averaging Period	Return Period (years)	Temperatures (°F) Maximum	Minimum
Hourly	50	101	-19
	100	102	-21
2-Hour	50	100	-19
	100	102	-21
4-Hour	50	100	-18
	100	101	-21
8-Hour	50	98	-18
	100	99	-20
12-Hour	50	95	-17
	100	96	-19
24-Hour	50	88	-13
	100	89	-16

TABLE 1-2

SEABROOK EXTREME TEMPERATURE ANALYSIS
HYPOTHETICAL HOTTEST CONTIGUOUS 24-HOUR PERIOD
IN ASSOCIATION WITH THE
100-YEAR RETURN PERIOD MAXIMUM
HOURLY TEMPERATURE*

HOUR	TEMPERATURE (°F)
1	76
2	79
3	84
4	87
5	92
6	94
7	99
8	101
9	102
10	102
11	102
12	100
13	99
14	94
15	89
16	86
17	84
18	82
19	80
20	79
21	82
22	79
23	77
24	78

* Based on Annual Maximum Hourly Temperatures for Pease AFB (Portsmouth, N.H.) for period 1957-1981.

TABLE 1-3

SEABROOK EXTREME TEMPERATURE ANALYSIS
HOTTEST CONTIGUOUS 24 HOURS IN ASSOCIATION WITH
THE HOTTEST ONE-HOUR TEMPERATURE
OBSERVED DURING 1957 THROUGH 1981 AT PEASE AFB

YEAR	DATE	HOUR	TEMPERATURE (^{o}F)
1964	June 30	15	89
		16	89
		17	89
		18	85
		19	81
		20	80
		21	77
		22	76
		23	76
	July 1	00	74
		1	76
		2	75
		3	75
		4	74
		5	73
		6	76
		7	80
		8	88
		9	92
		10	93
		11	96
		12	98
		13	101
		14	100

TABLE 1-4

SEABROOK EXTREME TEMPERATURE ANALYSIS
SUMMARY OF
FREQUENCY DISTRIBUTION
OF HOURLY TEMPERATURES
FOR PEASE AFB AND SEABROOK SITE

TEMPERATURE RANGE (°F)	FREQUENCY (PERCENT)	
	PEASE AFB	SEABROOK SITE
≥88	.463	.250
≥91	.104	.067
≤ 0	.356	.394
≤-5	.111	.126

DATA BASE: Seabrook Site: November 1, 1972 - November 30, 1974 (inclusive and April 1, 1979 - June 30, 1982 (inclusive); 46,003 valid hourly observations

Pease AFB: April 1, 1956 - December 31, 1981 (inclusive); 225,093 valid hourly observations.

2.0 STUDY METHODOLOGY

2.1 Selection of Variables and Data Bases

This study is concerned with severe summer and winter ambient temperature conditions and is limited to this particular meteorological parameter. Although wind and moisture conditions occurring simultaneously with severe temperature conditions may exacerbate or mitigate the effect of the severe temperatures upon certain structures systems or components, these additional effects are not addressed in the present study.

In the case of certain safety-related structures, systems, or components, use of the extreme maximum or minimum dry bulb temperature based upon near-instantaneous or even hourly average temperature is inappropriate. For these systems, extreme temperatures expected over averaging periods of up to twenty-four hours may more realistically reflect the sensitivity of such systems to severe dry bulb conditions. In many previous studies, including those referenced in NUREG/CR-1390[1], the statistical analysis of expected extreme dry bulb conditions has been based upon either airport temperature observations or observations of maximum and minimum temperatures taken by cooperative climatological observers without consideration of the time period over which these observations are valid. Generally, these observations are implicitly assumed to loosely represent "hourly" temperatures.

Observations of temperatures by the Federal Aviation Administration, National Weather Service, or military personnel are generally made a few minutes prior to the hour and represent, essentially, an instantaneous value. Observations by cooperative observers are taken from maximum/minimum thermometers and represent an averaging period of only a few minutes, at most, determined by the response characteristics of the shelter and thermometer.

Because of the need for an extensive historical data base to provide a reasonable degree of confidence in estimating the probable magnitude of rarely occurring temperatures, onsite meteorological data (more accurately representing true one-hour averages) cannot be used. Airport or climatological observer data (representing instantaneous or near-instantaneous readings) are the only recourse. The present study, therefore uses these data but interprets the results considering the limitations inherent in the data.

For the meteorological variable of dry bulb temperature, then, this study provides the following analyses:

- Representativeness analysis of Pease AFB maximum and minimum temperatures based on data from other regional stations.

- Computation of the 50- and 100-year return period maximum and minimum dry bulb temperatures based on Pease airport data to represent conditions expected to persist for averaging time periods of 1, 2, 4, 8, 12, and 24 hours.

- Determination of the five warmest and five coldest 24 hour periods observed over the 25 year Pease AFB data base and presentation of the hourly data comprising these periods.

- Presentation of the hourly data comprising the warmest contiguous 24 hour period containing the highest observed hourly temperature.

2.2 Data Bases

2.2.1 Available Raw Data

The regional dry bulb temperature data bases listed in Table 2-1 were obtained from the National Climatic Center (NCC). These stations listed are geographically distributed about the Seabrook site as shown in the map provided in Figure 2-1. Information obtained from the National Climatic Center indicates that no other government sponsored long-term data collection programs exist within the site region.

Inspection of Table 2-1 reveals that temperature data collected at Greenland, N.H. (cooperative observer) and the New Castle Coast Guard Station are not suitable for statistical analysis of extreme temperatures. The period of record at Greenland is only 9 years--far short of the desired long-term data record. Intermittent observations at New Castle result in the likelihood that true daily maximum and minimum temperatures were not reliably observed. The remaining stations, Pease AFB, Sanford, ME, and Rockport, MA, were used to develop the analyses presented in this study. Each of these three stations has at least a 26-year data record available for use.

2.2.2 Previously Analyzed Data

Dry bulb temperature data for meteorological stations in New England have been analyzed by Nicodemus and Guttman of the National Climatic Center. The list of stations considered is presented in Table 2-2[(2)]. The stations analyzed by the NCC do not include Rockport, MA, Pease AFB or Sanford, ME. This NCC analysis forms the foundation for the design basis extreme temperatures recommended by NUREG/CR-1390.

The purpose in reviewing data from the NCC study was to establish whether stations in relatively close proximity to the Seabrook site and in a coastal environment were used in drawing the isotherm analyses found in NUREG/CR-1390, and whether a pronounced maritime effect is evident in New England coastal observations of extreme temperatures. The results of this analysis are discussed in Chapter 3.

2.2.3 Representativeness Analysis

Temperature data for Pease AFB were selected for this analysis on the basis of it being the closest station to the site having the required hour-by-hour temperature data. Temperature data from other stations in the site region were analyzed and compared to the Pease AFB data to demonstrate the regional representativeness of the Pease AFB data. This analysis was based on the following considerations:

- Proximity of measurement
- Similarity of measurement topography
- Similarity of measured extremes
- Similarity of expected extreme statistics

2.3 Estimation of Return Period Statistics

2.3.1 Assumption of Data Distribution Characteristics

Extreme and near-extreme values of climatological variables are generally considered to be best fit by the Fisher & Tippett Type I and Type II extreme value distributions[3,4]. The Type II distribution is appropriate for data with a known upper or lower bound (e.g. extreme wind speeds)[5]. The Type I distribution is appropriate for extreme maximum and minimum temperatures.

The equation representing the cumulative probability from the Fisher-Tippett Type I distribution is as follows:

$$F(x) = \exp\left[-e^{-\left(\frac{x-\alpha}{\beta}\right)}\right]$$

where:

$F(x)$ is the probability that a selected value of x will not be reached

α is the mode of the distribution

β is the scale factor of the distribution

This distribution was fit to the extreme temperature data according to the procedure developed by Lieblein[6]. The computational methodology followed is described in more detail in the following section.

2.3.2 Computational Methodology

The computational methodology followed for determination of 50- and 100-year return period hourly temperatures and averaging period temperatures is described in this section.

2.3.2.1 Hourly Temperatures

Computation of the 50- and 100-year return period extreme temperatures for Pease AFB at Portsmouth, N.H. followed the methodology summarized below:

a. Pease AFB data were obtained on magnetic tape from the National Climatic Center in TD-1440 format. This provided a data base consisting of hourly observations of dry bulb temperature.

b. The data tapes were reformatted to CD-144 format (one hour of data per record).

c. Each calendar year of data was searched (using the SPSS system[7]) to determine the annual maximum and minimum hourly temperature observations. The chronological order of the observations was preserved during this process.

d. These samples were divided into subgroups of six entries each (plus a remainder group, if required).

e. Each subgroup was arranged in ascending order of magnitude for the extreme maximum analysis and descending order for the extreme minimum analysis.

f. The order statistics weights developed by Lieblein were applied according to the procedure outlined in Reference 4.

g. Temperatures corresponding to return periods of 50- and 100-years were computed.

2.3.2.2 Averaging Period Temperatures

Using the hourly records of observations available for Pease AFB, mean dry bulb temperatures were computed for running averaging periods of 2, 4, 8, 12 and 24 hours using the SPSS system. If a dry bulb temperature observation was missing in a particular averaging period, the average for that period was discarded. This occurred only rarely, as will be demonstrated in Chapter 3. This averaging methodology, for an example non-leap year, resulted in the generation of (8760 - (N - 1) - M) average dry bulb values for each different averaging period (where N is the averaging period length and M is the number of averaging periods discarded due to missing data).

The dry bulb temperatures for each averaging period for each calendar year were searched to determine the extreme maximum and extreme minimum values for that year. These data sets were then used in the computations described in Section 2.3.2.1(c) through 2.3.2.1(g) to yield 50- and 100-year return period dry bulb temperatures representative of the 2, 4, 8, 12 and 24 hour averaging periods.

2.4 Derivation of Temperature Progression Data

The Pease AFB hourly temperature data for the period, April 1, 1956 through December 31, 1981, were further utilized for the generation of several hourly temperature progressions and frequency distributions of hourly temperatures. Initially, the sets of 24 hourly temperatures comprising the periods of the five highest and five lowest 24-hour average temperatures were determined.

Since none of the hourly temperature progressions derived above for the five warmest 24-hour periods contained the maximum hourly temperature of 101°F, an additional hourly temperature progression was required. This hourly temperature progression was determined by analyzing the temperatures recorded for the hours surrounding the hour of the record maximum observed temperature. The warmest contiguous 24 hours period inclusive of the hour of the maximum observed temperature was then selected.

A hypothetical hourly temperature progression was also required to demonstrate the expected temporal variation in temperature during the hottest 24-hour period containing the 100-year return period maximum hourly temperature. Initially, the 24 hours over the entire 25-year data base which resulted

in the maximum 24-hour average temperature were selected. Since the maximum hourly temperature recorded during this 24-hour period was 2°F lower than the 100-year return period maximum temperature, 2°F was added to all hourly temperatures recorded during this period. This resulted in the expected hourly temperature progression for the warmest contiguous 24-hours which included the 100-year return period maximum hourly temperature.

TABLE 2-1

GENERAL STATION INFORMATION

	Station	Period of Record	Location			Type of Temperature Data
			Latitude	Longitude	Elevation (ft. msl.)	
1.	Seabrook, N.H.*	November 1972 - November 1974	42° 54' N	70° 51' W	40	Hourly
	(Onsite)	April 1979 - June 1982	42° 54' N	70° 51' W	53	
2.	Portsmouth, N.H. (Pease AFB)	April 1956 - June 1982	43° 05' N	70° 49' W	111	Hourly
3.	Portsmouth, N.H. (New Castle Coast Guard)	January 1966 - June 1982	43° 04' N	70° 42' W	30	Generally every three hours
4.	Sanford, ME	July 1953 - June 1982	43° 28' N	70° 47' W	280	Daily maximum and minimum
5.	Rockport, MA	January 1910 - June 1982	42° 39' N	70° 36' W	80	Daily maximum and minimum
6.	Greenland, N.H.	May 1973 - June 1982	43° 03' N	70° 50' W	60	Daily maximum and minimum

* Meteorological tower was dismantled in November 1974. A new meteorological tower was erected in April 1979.

TABLE 2-2

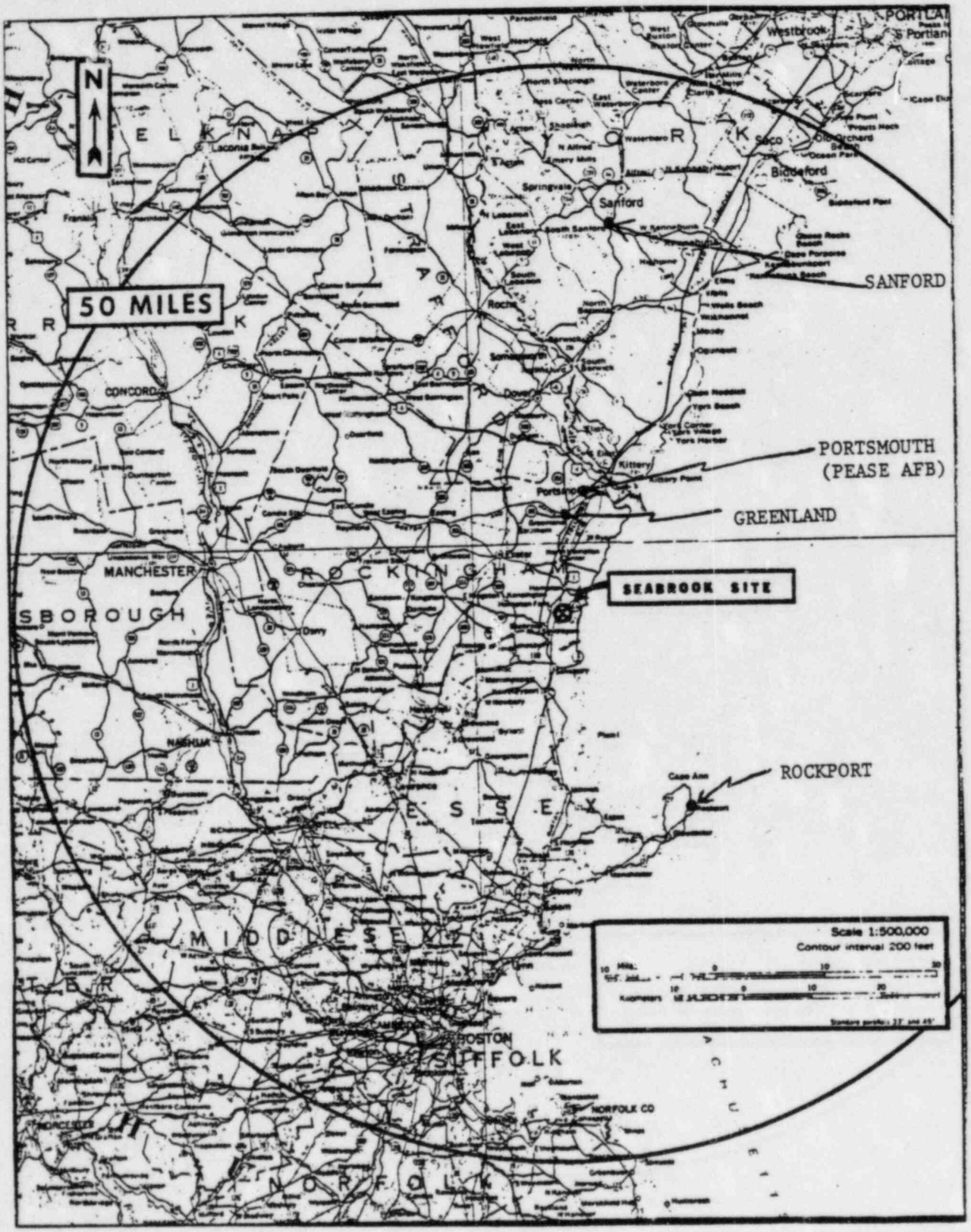
MAINE - NEW HAMPSHIRE - MASSACHUSETTS
STATIONS CONSIDERED
IN NCC STUDY*

MAINE		NEW HAMPSHIRE		MASSACHUSETTS	
Station Number	Station Name	Station Number	Station Name	Station Number	Station Name
170371	Bar Harbor	270690	Berlin	190049	Adams
172426	Eastport	270703	Bethlehem	190120	Amherst
172765	Farmington	271683	Concord	190736	Blue Hill
173046	Gardiner	272174	Durham	190770	Boston
173353	Greenville	272999	First Conn Lk.	191447	Chestnut Hill
173897	Houlton	273177	Franklin	191561	Clinton
174566	Lewiston	273850	Hanover	192642	Fall River
174927	Madison	274399	Keene	192806	Fitchburg
175304	Millinocket	274475	Lakeport	192975	Framingham
176425	Old Town	275072	Manchester	193505	Haverhill
176905	Portland	275500	Monroe	193713	Hoosac Tunnel
176937	Presque Island	275712	Nashua	194105	Lawrence
177174	Ripogenus Dam	276818	Pinkham Notch	194313	Lowell
177250	Rockland			195159	Mantucket
179891	Woodland			195246	New Bedford
				197370	Shelburne Falls
				198046	Springfield
				198181	Stockbridge
				198367	Taunton
				198580	Turners Falls

* Reference (2)

FIGURE 2-1

STATION LOCATOR MAP



3.0 STUDY RESULTS

3.1 Representativeness Analysis

Pease AFB, the offsite source of temperature data, is located ten miles north of the Seabrook site, just outside the city of Portsmouth, New Hampshire. Pease AFB lies approximately five miles inland. The Base and the surrounding area is topographically very similar to the area surrounding the Seabrook site which lies approximately 2 miles inland. One exception is that a relatively large water body, Great Bay, lies directly to the southwest of the base. The presence of this Bay may affect extreme temperatures recorded at Pease under conditions of southerly or westerly winds.

Despite this difference, the representativeness of Pease AFB can be demonstrated by comparing the frequency of extreme daily maximum and minimum temperatures. Tables 3-1 presents the frequency of daily maximum temperatures equal to or greater than 80°F and 90°F, and daily minimum temperatures less than or equal to 10°F and 0°F for the Seabrook site, Pease AFB and the other area stations.

Pease AFB displays a significantly larger frequency of extreme daily maximum temperatures but an almost identical frequency of exteme daily minimum temperatures compared to the Seabrook site. The Greenland, N.H. station which is located three miles south of Pease AFB has a similar distribution to that of Pease AFB but with a slightly higher frequency of extreme daily minimum temperatures. The percentages for Greenland, N.H. are, however, based on a very limited number of observations. The Rockport, Massachusetts station, which is located 27 miles southeast of the Seabrook site, has the

lowest frequency of extreme daily maximum and minimum temperatures in the ranges considered. This is mainly due to the close proximity of this station to the Atlantic Ocean, which acts to greatly moderate its temperature extremes. Unlike the Seabrook site and Pease AFB, this station does not have intervening land between it and the Atlantic Ocean for winds from both the north and east directions. The Sanford, Maine station on the other hand is located well inland in an area with significantly higher terrain than any of the other stations. The frequencies of extreme daily maximum and minimum temperatures are consequently the highest for this station, as shown in Table 3-1. The inland location of this site greatly reduces the moderating effects of the Atlantic Ocean.

The representativeness of the Pease data to the onsite conditions is further confirmed by the comparison of the frequency distributions of the entire temperature data bases. Table 3-2 presents such a frequency distribution of hourly temperatures for the entire period of record for the Seabrook site and Pease AFB. The frequency distributions for these stations are very similar with Pease AFB showing only a slightly higher frequency of hourly temperature extremes. The similarily in distributions provides further evidence of the representativeness of Pease AFB.

3.2 Fifty and 100-Year Return Period Temperatures

Table 3-3 presents the 50- and 100-year return period maximum and minimum temperatures computed for Pease AFB. On the basis of the representativeness analysis discussed in Section 3.1, these extreme temperatures are reasonably representative of the site area.

Table 3-4 presents the number of missing running averages for averaging periods of 1, 2, 4, 8, 12 and 24 hours for Pease AFB for the period, January 1, 1957 through December 31, 1981. The numbers in parenthesis on this table represents the percentage of possible averaging periods which were missing. The frequency of missing values ranges from 0.2 percent for hourly averages to 2.9 percent for running 24-hour averages.

The isotherm maps in the NUREG/CR-1390 analysis indicate 100-year return period maximum and minimum hourly temperatures of 106°F and -32°F respectively. Examination of the data base used in developing these maps however, revealed no coastal station within 40 miles of the Seabrook site. The closest station to the site is Haverhill, Massachusetts, approximately 14 miles southwest. This station however is located about 10 miles farther inland than the Seabrook site. Proximity to the coastline is a significant determinant of the degree and frequency of temperature extremes. This is especially true, and may be clearly demonstrated for, extreme minimum temperatures by comparing the 100-year return period minimum temperatures for pairs of relatively nearby stations - one coastal and one inland-shown in Table 3-5. For instance, in the case of New Bedford, MA, the 100-year return minimum is -19.5°F. Comparison with Taunton, MA (about 20 miles inland from New Bedford) reveals that Taunton's expected minimum temperature for the same return period is almost 18°F colder. Similar pronounced differences in extreme minimum temperatures are found north of the Seabrook site. These may be seen by comparing Portland and Rockland values (both coastal stations) with those computed for stations farther inland such as Lewiston and Gardiner. (Lewiston and Gardiner are approximately 20 and 25 miles inland, respectively).

The effect upon extreme maximum temperatures appears less pronounced. Nantucket, MA, of course, shows a very significant maritime influence on both maximum and minimum temperatures with a 100-year return values of 98.5 and -13.1°F, respectively. This is the most moderate expected 100-year return minimum temperature and the third lowest maximum temperature of all of the 48 stations analyzed by Nicodemus and Guttman[1] in the states of Maine, New Hampshire and Massachusetts.

3.3 Temperature Progression

Table 3-6 presents the hourly temperature progressions for the five coldest and warmest 24-hour periods for Pease AFB observed for the period April 1, 1956 through December 31, 1981. The warmest 24-hour period averaged 86.62°F and occurred from August 2, 1975, hour 4 through August 3, 1975, hour 3. The coldest 24-hour period averaged -8.08°F and occurred from January 8, 1968 hour 11, through January 9, 1968, hour 10. The warmest 24-hour period was used to generate the hypothetical hourly temperature progression for the warmest contiguous 24-hours containing the 100-year return period maximum hourly temperature of 102°F. Since the observed warmest 24-hour period contained a maximum observed hourly temperature of only 100°F, each hourly temperature was increased by 2°F to produce an hourly temperature progression which would contain a maximum hourly temperature of 102°F, the 100-year return maximum hourly temperature for Pease AFB. Table 3-7 presents the hourly temperature progression for the warmest contiguous 24-hours containing the maximum observed hourly temperature, 101°F recorded at Pease AFB. This 24-hour period averaged 83.88°F, and began on June 30, 1964 hour 15 and ended July 1, 1964 hour 14. This 24-hour average was slightly cooler than the fifth warmest 24-hour period listed in Table 3-6.

TABLE 3-3

SEABROOK EXTREME TEMPERATURE ANALYSIS
MAXIMUM AND MINIMUM TEMPERATURES
FOR 50- AND 100-YEAR RETURN PERIOD
FOR PEASE AIR FORCE BASE*

Averaging Period	Return Period (years)	Upper and Lower Temperatures (°F) Maximum	Minimum
Hourly	50	101	-19
	100	102	-21
2-Hour	50	100	-19
	100	102	-21
4-Hour	50	100	-18
	100	101	-21
8-Hour	50	98	-18
	100	99	-20
12-Hour	50	95	-17
	100	96	-19
24-Hour	50	88	-13
	100	89	-16

* DATA BASE: January 1, 1957 through December 31, 1981

TABLE 3-2

FREQUENCY DISTRIBUTION
OF HOURLY TEMPERATURES
FOR SEABROOK AND PEASE AFB*

Temperature Interval (deg. F)	Frequency of Occurrence (%) Seabrook	Frequency of Occurrence (%) Pease AFB
(-16) - (-12)	0.0	<0.1
(-11) - (-7)	<0.1	<0.1
(-6) - (-2)	0.2	0.2
(-1) - 3	0.5	0.4
4 - 8	0.8	1.0
9 - 13	1.7	1.9
14 - 18	2.5	2.8
19 - 23	4.0	4.2
24 - 28	5.0	5.7
29 - 33	8.2	8.4
34 - 38	9.9	9.5
39 - 43	10.0	8.6
44 - 48	8.7	8.0
49 - 53	8.8	8.2
54 - 58	9.0	8.5
59 - 63	9.4	9.1
64 - 68	8.3	8.5
69 - 73	6.6	6.7
74 - 78	3.7	4.3
79 - 83	1.9	2.5
84 - 88	0.8	1.2
89 - 93	0.2	0.3
94 - 98	0.0	<0.1
99 - 103	0.0	<0.1

* DATA BASE: Seabrook: November 1, 1972 - November 30, 1974 (inclusive) and April 1, 1979 - June 30, 1982 (inclusive); 46,003 valid hourly observations.

Pease AFB: April 1, 1956 - December 31, 1981 (inclusive); 225,093 valid hourly observations.

TABLE 3-3

SEABROOK EXTREME TEMPERATURE ANALYSIS
MAXIMUM AND MINIMUM TEMPERATURES
FOR 50- AND 100-YEAR RETURN PERIOD
FOR PEASE AIR FORCE BASE*

Averaging Period	Return Period (years)	Temperatures (°F) Maximum	Minimum
Hourly	50	101	-19
	100	102	-21
2-Hour	50	100	-19
	100	102	-21
4-Hour	50	100	-18
	100	101	-21
8-Hour	50	98	-18
	100	99	-20
12-Hour	50	95	-17
	100	96	-19
24-Hour	50	90	-13
	100	92	-16

* DATA BASE: January 1, 1957 through December 31, 1981

TABLE 3-4

SEABROOK EXTREME TEMPERATURE ANALYSIS
NUMBER OF MISSING RUNNING AVERAGES
FOR VARIOUS AVERAGING PERIODS
FOR PEASE AIR FORCE BASE*

Averaging Period (Hours)	Number of Missing
1	427 (.2%)
2	784 (.4%)
4	1422 (.6%)
8	2590 (1.2%)
12	3665 (1.7%)
24	6537 (2.9%)

* DATA BASE: January 1, 1957 through December 31, 1981

TABLE 3-5

100-YEAR RETURN PERIOD
MAXIMUM AND MINIMUM TEMPERATURES*
FOR SELECTED NEW ENGLAND STATIONS

STATION	LOCATION			GENERAL PERIOD OF RECORD	YEARS OF TEMPERATURE DATA		100-YEAR RETURN PERIOD TEMPERATURES (degrees F)	
	Latitude	Longitude	Elevation (ft. msl.)		Maximum	Minimum	Maximum	Minimum
Gardiner, ME	44° 13' N	69° 47' W	140	1896 - 1976	81	80	106.3	-49.5
Lewiston, ME	44° 06' N	70° 13' W	180	1896 - 1976	81	81	103.9	-37.6
Portland, ME	43° 39' N	70° 19' W	57	1872 - 1977	104	106	104.8	-32.4
Rockland, ME	44° 06' N	69° 07' W	40	1937 - 1976	38	38	104.3	-31.2
Boston, MA	42° 22' N	71° 02' W	15	1873 - 1977	105	105	105.5	-20.8
Farmingham, MA	42° 17' N	71° 25' W	170	1893 - 1976	84	83	105.4	-32.2
Nantucket, MA	41° 15' N	70° 04' W	43	1887 - 1977	91	90	98.5	-13.1
New Bedford, MA	41° 38' N	70° 56' W	120	1893 - 1976	84	81	104.7	-19.5
Taunton, MA	41° 54' N	71° 04' W	20	1893 - 1976	84	84	103.6	-37.3

* Reference (2)

TABLE 3-6

PUBLIC SERVICE CORPORATION OF NEW HAMPSHIRE
SEABROOK STATION UNITS 1 AND 2

FIVE COLDEST 24-HOUR PERIODS

Average	-8.08	-7.12	-5.50	-2.70	-2.50
Year	1968	1957	1980	1967	1981
Period Ends	Jan 9	Jan 15	Dec 26	Feb 13	Jan 5
Hour					
00					
01					
02					
03					
04					
05					
06			-2		-4
07			-5		-2
08			-7		-4
09			-7		-4
10			-7	0	-2
11	-6		-7	1	-2
12	-5		-5	2	1
13	-4		-4	2	2
14	-4		-4	3	3
15	-4		-4	3	3
16	-5		-5	3	2
17	-6		-5	2	0
18	-7		-7	0	0
19	-8		-7	-1	-2
20	-10		-7	-1	-2
21	-10		-7	-2	-5
22	-10	-4	-7	-3	-7
23	-10	-7	-6	-4	-7
00	-10	-8	-5	-5	-7
01	-9	-10	-5	-6	-5
02	-9	-11	-5	-7	-5
03	-10	-13	-5	-8	-5
04	-9	-14	-5	-8	-4
05	-10	-15	-4	-8	-4
06	-10	-15		-9	
07	-12	-16		-9	
08	-10	-14		-7	
09	-9	-12		-3	
10	-7	-8			
11		-5			
12		-1			
13		0			
14		1			
15		0			
16		-3			
17		-4			
18		-4			
19		-4			
20		-2			
21		-2			
22					
23					

FIVE WARMEST 24-HOUR PERIODS

Average	86.62	85.87	85.25	84.25	83.91
Year	1975	1977	1964	1978	1981
Period Ends	Aug 3	Jul 21	Jul 19	Jul 22	Jul 9
Hour					
00					
01					
02					
03					
04	74				
05	77				
06	82				
07	85				
08	90				
09	92				
10	97				
11	99			88	
12	100			90	
13	100		93	91	
14	100		94	93	
15	98		94	93	
16	97	94	94	93	
17	92	92	92	91	
18	87	89	89	86	
19	84	87	87	85	87
20	82	85	85	84	86
21	80	83	84	82	82
22	78	82	84	82	80
23	77	80	82	82	80
00	80	79	81	82	79
01	77	79	80	80	78
02	75	78	79	79	77
03	76	77	79	79	75
04		77	78	79	74
05		77	77	78	75
06		77	76	78	77
07		80	78	79	79
08		84	80	81	80
09		87	84	82	82
10		91	90	85	85
11		95	92		90
12		96	94		89
13		96			93
14		98			95
15		98			94
16					94
17					93
18					90
19					
20					
21					
22					
23					

DATA BASE: April 1, 1956 through December 31, 1981

TABLE 3-7

SEABRROK EXTREME TEMPERATURE ANALYSIS
HOTTEST CONTIGUOUS 24 HOURS IN ASSOCIATION WITH
THE HOTTEST ONE-HOUR TEMPERATURE
OBSERVED DURING 1957 THROUGH 1981 AT PEASE AFB

YEAR	DATE	HOUR	TEMPERATURE (°F)
1964	June 30	15	89
		16	89
		17	89
		18	85
		19	81
		20	80
		21	77
		22	76
		23	76
	July 1	00	74
		1	76
		2	75
		3	75
		4	74
		5	73
		6	76
		7	80
		8	88
		9	92
		10	93
		11	96
		12	98
		13	101
		14	100

4.0 CONCLUSION

The 50- and 100-year return period maximum and minimum temperatures recommended for use in the confirmation of the adequacy of safety-related equipment design are as follows:

Averaging Period	Return Period (years)	Temperatures (^{o}F) Maximum	Minimum
Hourly	50	101	-19
	100	102	-21
2-Hour	50	100	-19
	100	102	-21
4-Hour	50	100	-18
	100	101	-21
8-Hour	50	98	-18
	100	99	-20
12-Hour	50	95	-17
	100	96	-19
24-Hour	50	88	-13
	100	89	-16

These temperatures are based on data collected at Pease AFB which are reasonably representative of temperatures observed at the Seabrook site.

The 100-year return period maximum and minimum temperatures recommended by NUREG/CR-1390 for use at the site do not adequately consider the moderating effect of water for New England coastal sites. Examination of data presented in Table 3-5 resulted in the conclusion that the moderating effect is very pronounced in its effect on extreme minimum temperatures and not as important for extreme maximum temperatures.

5.0 REFERENCES

1. Nicodemus, M.L. and N. B. Guttman, "Probability Estimates of Temperature Extremes for the Contiguous United States", NUREG/CR-1390, National Climatic Center, Asheville, N.C., May 1980.

2. Private Communication with M.L. Nicodemus, Statistical Climatology Branch, National Climatic Center, Asheville, N.C., October 13, 1982.

3. United States Weather Bureau, "Fitting of Climatological Extreme Value Data", Climatological Services Memorandum No. 89, Washington, D.C. August 11, 1961.

4. Thom, H.C.S., "Some Methods of Climatological Analysis", Technical Note No. 81, World Meteorological Organization, Geneva, Switzerland, 1966.

5. Thom, H.C.S., "Distributions of Extreme Winds in the United States", Journal of the Structural Division, Proceedings of the American Society of Civil Engineers, April 19( ).

6. Lieblein, J. "Efficient Methods of Extreme-Value Methodology", National Bureau of Standards, NBSIR 74-602, U.S. Department of Commerce, Washington, D.C. 1974.

7. University of Kansas Academic Computing Center, Statistical Package for the Social Sciences Batch System-Release 9.0, Lawrence, Kansas, December 1981.